

Supplementary Information for

Improving the taxonomy of fossil pollen using convolutional neural networks and superresolution microscopy

Ingrid C. Romero<sup>a,1</sup>, Shu Kong<sup>b,c</sup>, Charless C. Fowlkes<sup>c</sup>, Carlos Jaramillo<sup>d,e,f</sup>, Michael A. Urban<sup>a,g</sup>, Francisca Oboh-Ikuenobe<sup>h</sup>, Carlos D'Apolito<sup>i</sup>, Surangi W. Punyasena<sup>a,1</sup>

<sup>1</sup>Ingrid C. Romero, <sup>1</sup>Surangi W. Punyasena  
Email: romerov2@illinois.edu, spunya1@illinois.edu

**This PDF file includes:**

Supplementary text  
Figures S1 to S15  
Tables S1 to S3  
Legend for Movie S1  
Legends for Datasets S1 to S7  
SI References

**Other supplementary materials for this manuscript include the following:**

Movies S1  
Datasets S1 to S7

**Supplementary Information**

**Additional Machine Experiments**

In our machine experiments, we tried test-time augmentation to see if this improved the performance of the models. For this, we mirrored the pollen images by flipping them, creating multiple copies as input to feed into the model. We then calculated the average softmax score over their output as the final prediction. We found that test-time augmentation did not improve the results. This may be because the pollen images in a single viewpoint held enough information for classification without further augmentation. We therefore reported performance accuracy without test-time augmentation.

## Expanded Discussion of Results

### Age of the fossil vs. classification confidence

We plotted the classification confidence scores (cs) against the age of the fossil specimens and used linear correlation to test if there was a relationship. We found that only the confidence scores of the *Macrolobium* identifications negatively correlated with age ( $r^2=0.98$ ,  $p<0.05$ ) (Fig. S8, Table S1). This negative correlation results from the low confidence scores of a *Macrolobium* fossil from the Langhian (15.97-13.82 Mya) (cs: 0.5) and higher values for five fossils from the Serravallian (13.82-11.63) (cs: 0.57-0.63) and Tortonian (11.63-7.25 Mya) (cs: 0.9 - 1.00) (Fig. S8, Table S1).

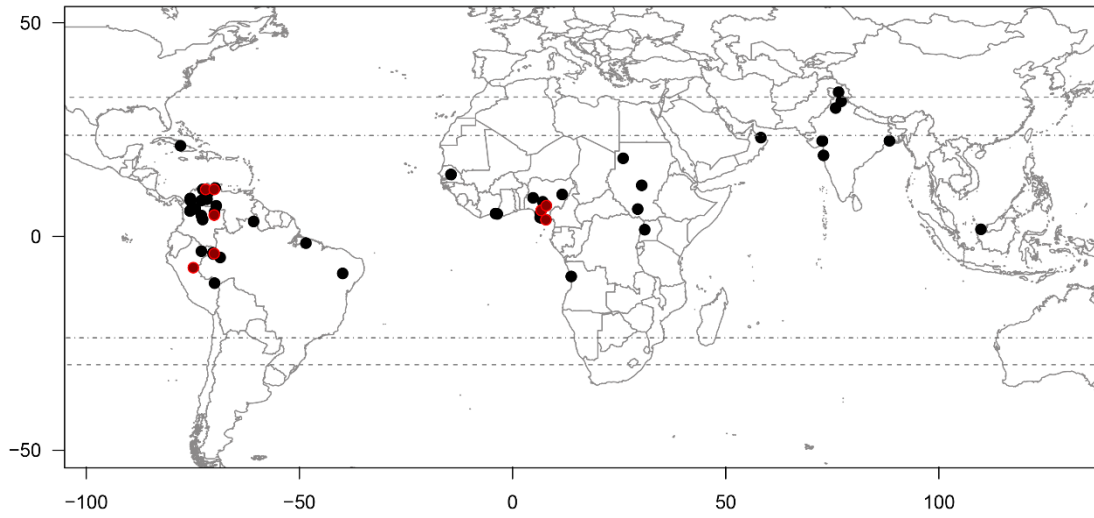
Fossil specimens identified as *Crudia* ( $r^2=-0.04$ ,  $p>0.05$ ) and *Berlinia* ( $r^2=-0.19$ ,  $p>0.05$ ) did not show significant relationships (Fig. S8). South American specimens identified as extant African genera were identified with lower classification confidence than African fossils identified as extant African genera (Fig. S8). South American fossils identified as the African genus *Berlinia* showed a decrease in classification confidence scores for the Burdigalian fossil (~0.85) and the Serravallian fossil (~0.6) (Table S1). Similarly, the two South American fossils identified as *Anthonotha* ( $r^2=-0.19$ ,  $p>0.05$ ) had consistently low confidence scores (cs: 0.5 - 0.6), while most of the African fossils have confidence scores  $>0.9$  (Fig. S8), Table S1). The confidence scores for the remaining *Anthonotha* specimens ranged from 0.5 to 1.00 (Fig. S8, Table S1).

### Classification problems in *Cynometra* and *Neochevalierodendron*

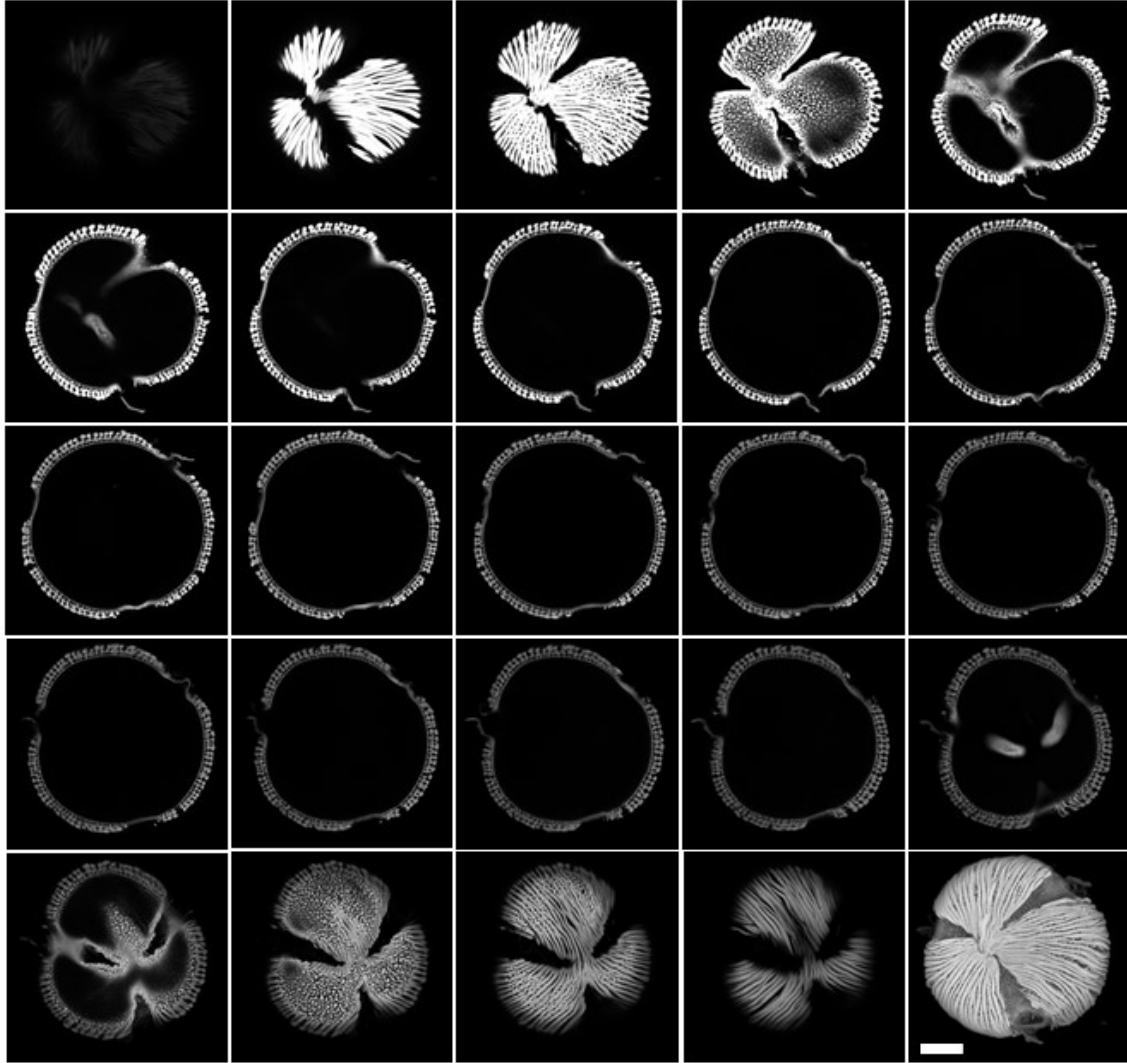
In all three CNN models, the pantropical genus *Cynometra* was consistently identified as the Neotropical *Macrolobium*, never as itself (Figs. 2, S3, S4). *Cynometra* is a taxonomically problematic genus that is considered polyphyletic (1–5). Three separate clades have been proposed (3, 5) and *Cynometra marginata*, the species that we analyzed, is in the Neotropical clade (5).

Our image training set, *Cynometra* was the smallest of the 16 genera. There are 90 recognized species, but we had access to a limited number of herbarium specimens, and few included flowers with good pollen preservation. We were able to image only eight grains from a single herbarium specimen (*Cynometra marginata*). Visually, the external and internal structures of the pollen walls of *C. marginata* and the species of *Macrolobium* are very similar (Fig. S5). This explains the CNN results and suggests that the taxonomic classification of this species may need to be reviewed.

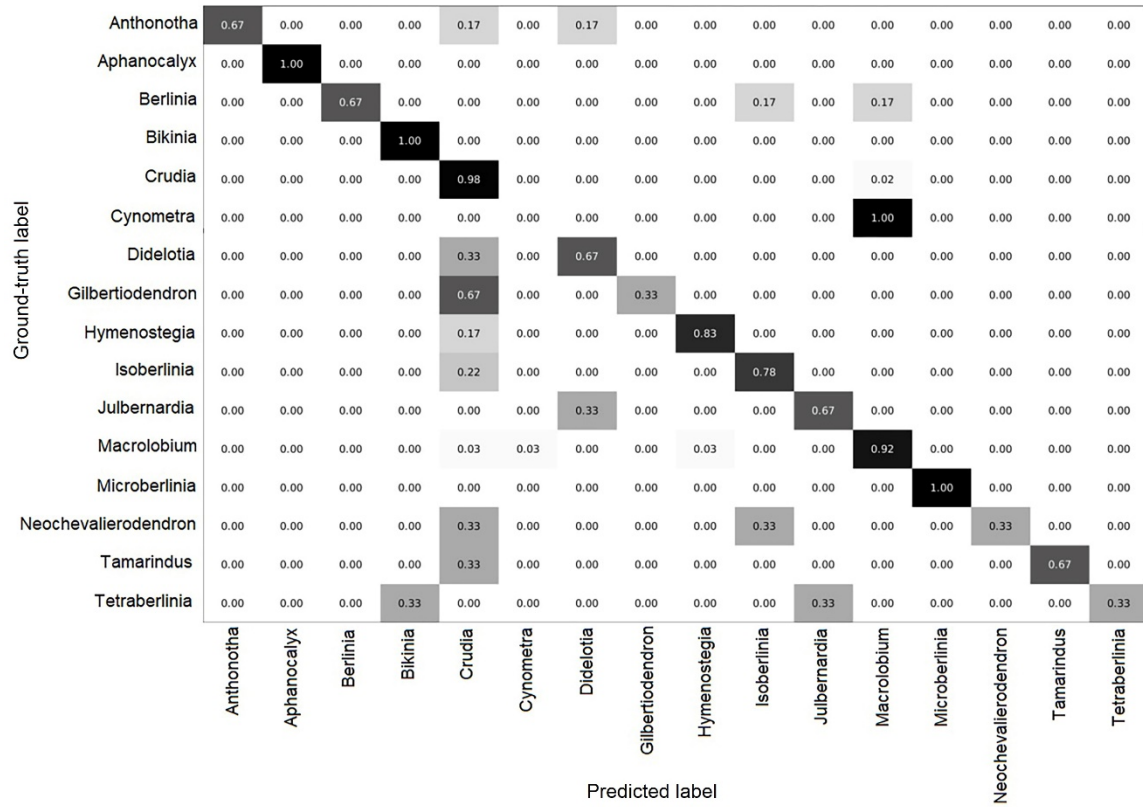
Another genus misclassified in all three models was the African genus *Neochevalierodendron*. The genus is monospecific with a single extant species, *Neochevalierodendron stephanii*. Molecular phylogenies estimate that the genus originated in the Eocene. However, the position of this genus within Amherstieae is largely uncertain (2, 3, 6, 7). *Neochevalierodendron* was misclassified as *Crudia*, *Isoberlinia*, *Anthonotha*, and *Macrolobium* in the three CNN models (Figs. 2, S3, S4). Visually, the external morphology of *Neochevalierodendron*, *Crudia*, *Isoberlinia*, and *Anthonotha* are similar (Fig. S7). Although the striation patterns of both genera appear similar in deeper planes, *Macrolobium* has thicker striae than *Neochevalierodendron* (Fig. S7). *Neochevalierodendron* and *Anthonotha* grains appear to be more prolate than *Isoberlinia*, *Crudia*, and *Macrolobium* (Fig. S7). Internally, the shape of the striae of *Neochevalierodendron* are baculate to slightly clavate, while in *Macrolobium* they are baculate and in *Anthonotha* clavate (Fig. S7). Fossil specimens identified as *Neochevalierodendron* had confidence scores  $<0.55$ , and the identifications did not show consistency among the models (Table S1).



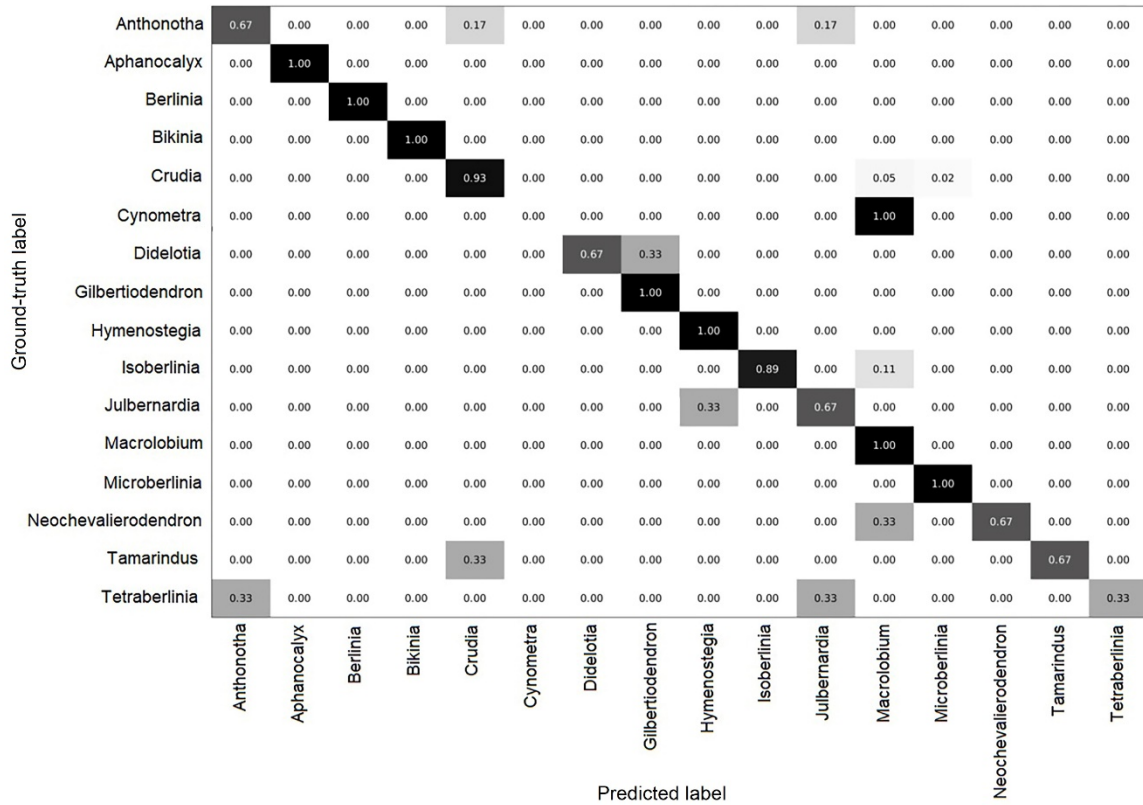
**Fig. S1.** Cenozoic paleogeography of *Striatopollis catatumbus*. Red dots indicate localities of the specimens analyzed in this study. Black dots indicate the fossil occurrence of *S. catatumbus* based on literature.



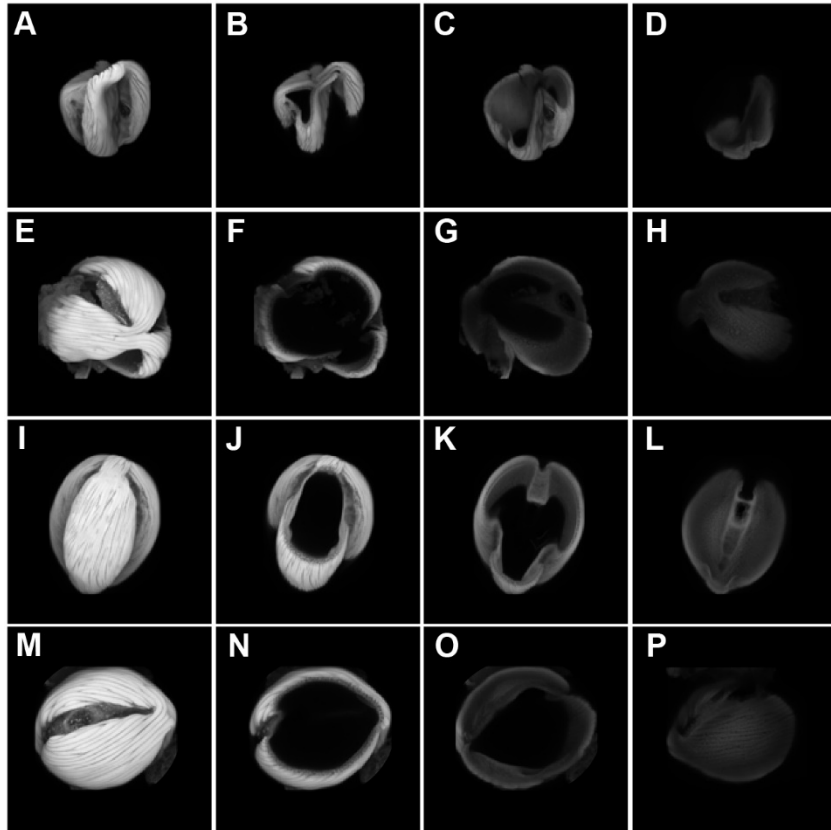
**Fig. S2.** Pollen image stack. Subsample of images from a single z-stack of an *Anthonotha macrophylla* pollen grain. A total of 114 images were taken; the slices shown represent approximately every fifth image. Note the ability of structured illumination fluorescence to capture the three-dimensional shape of the grain, including the far pollen wall. The final image (lower right-hand corner) is a maximum intensity projection of the top half of the grain. Each image pixel measures  $0.05\ \mu\text{m} \times 0.05\ \mu\text{m}$ . The original 114 images were taken at  $0.19\ \mu\text{m}$  increment in the z-plane. Bar scale:  $10\ \mu\text{m}$ .



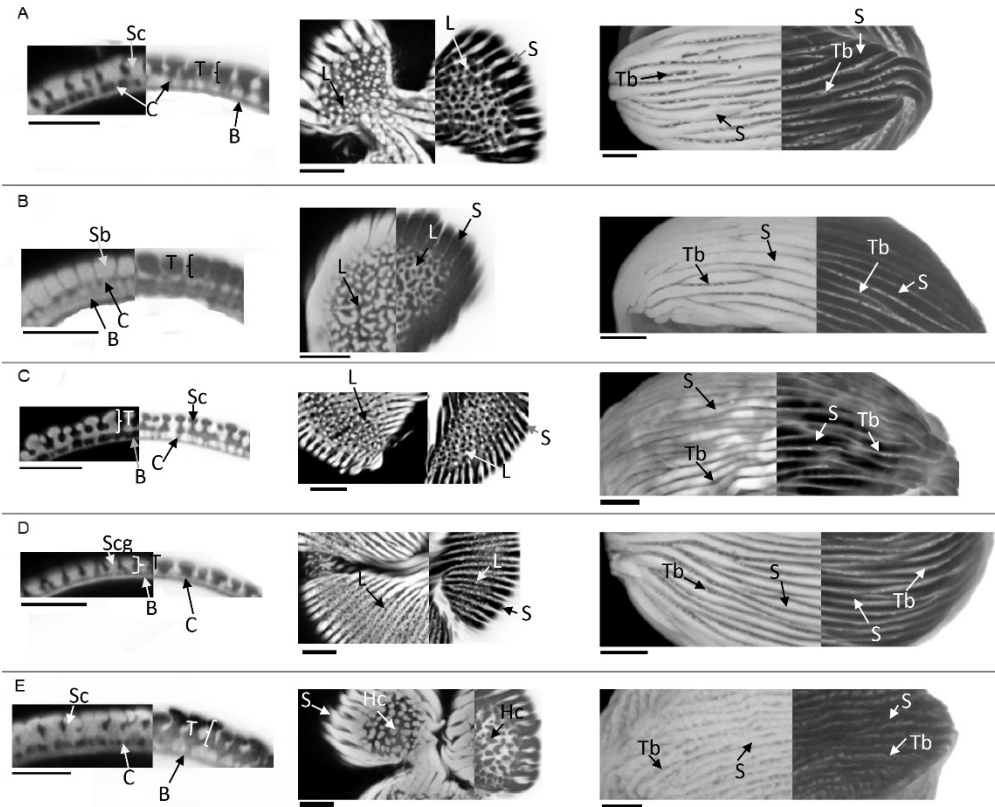
**Fig. S3.** Confusion matrix of classification accuracy for the Maximum Projection Model (MPM). Average accuracy was 83.58%.



**Fig. S4.** Confusion matrix of classification accuracy for the Multi-Slice Model (MSM). Average accuracy was 89.55%.

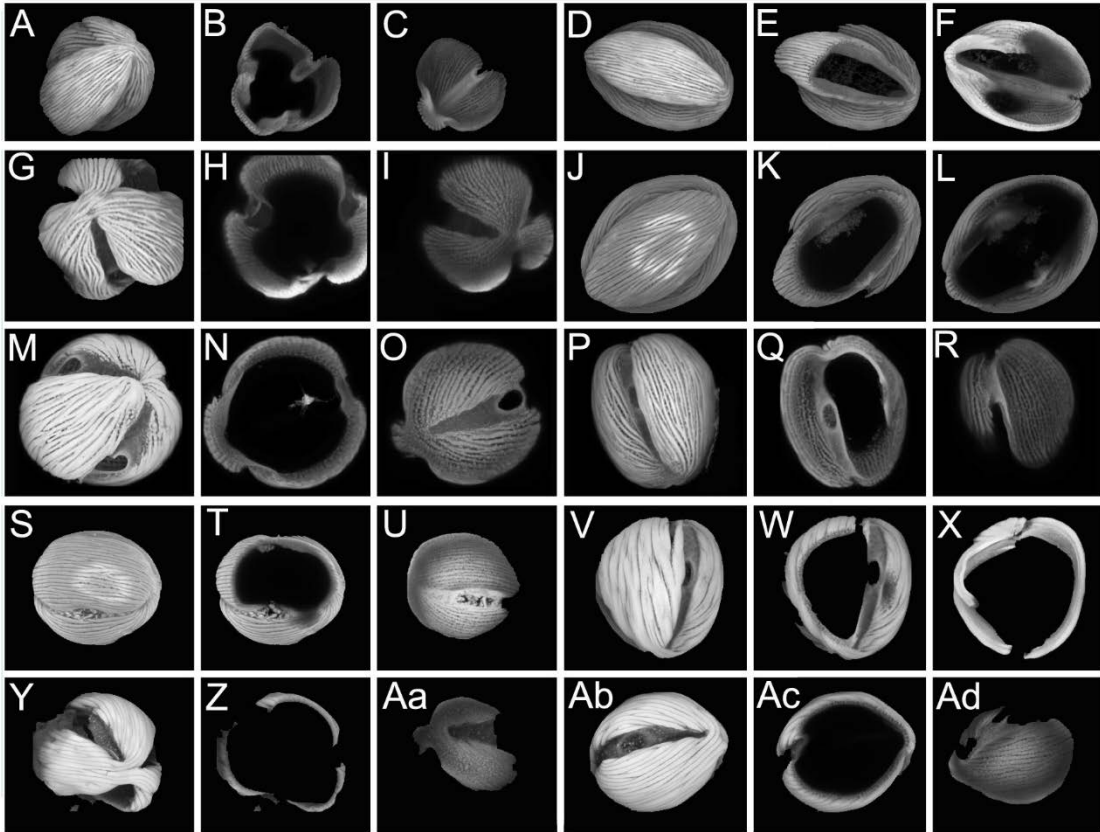


**Fig. S5.** Morphological comparison of images of *Cynometra* (A-D, I-L) and *Macrolobium* (E-H, M-P) used as inputs for the CNN models. Maximum intensity projections (A, E, I, M) and multi-slices (B - C, F - H, J - L, N - P).

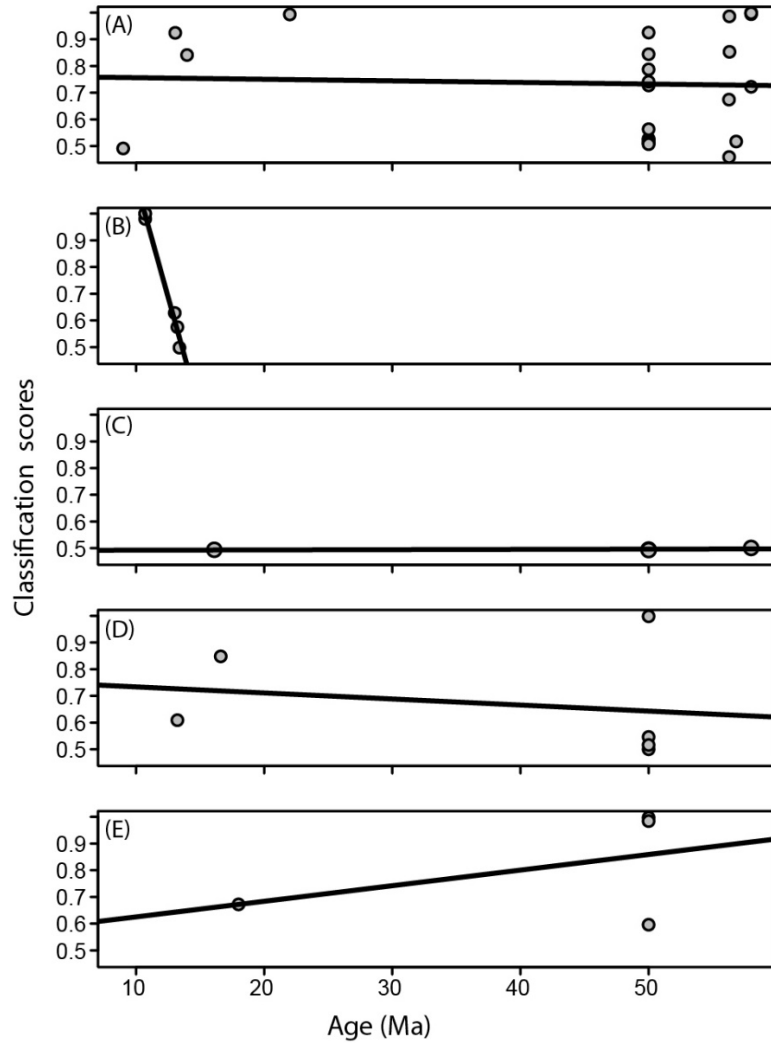


**Fig. S6.** Representation of the range of morphological variation in the internal and external structure of pollen wall within Amherstieae. View in Airyscan (left half) juxtaposed with the negative view (right half). The species are: *Isoberlinia angolensis* (A), *Macrolobium jenmanii* (B), *Anthonotha macrophylla* (C), *Crudia glaberrima* (D), *Berlinia confusa* (E). Parts of the pollen wall are labelled as: Foot layer (B), columellae (C), tectum (T), lumina (L), head of columellae (Hc), striae or furrow (S), stria clavate (Sc), stria clavate or gemate (Scg), stria baculate (Sb), base of the tectum (Tb). Bar scale: 5  $\mu$ m.

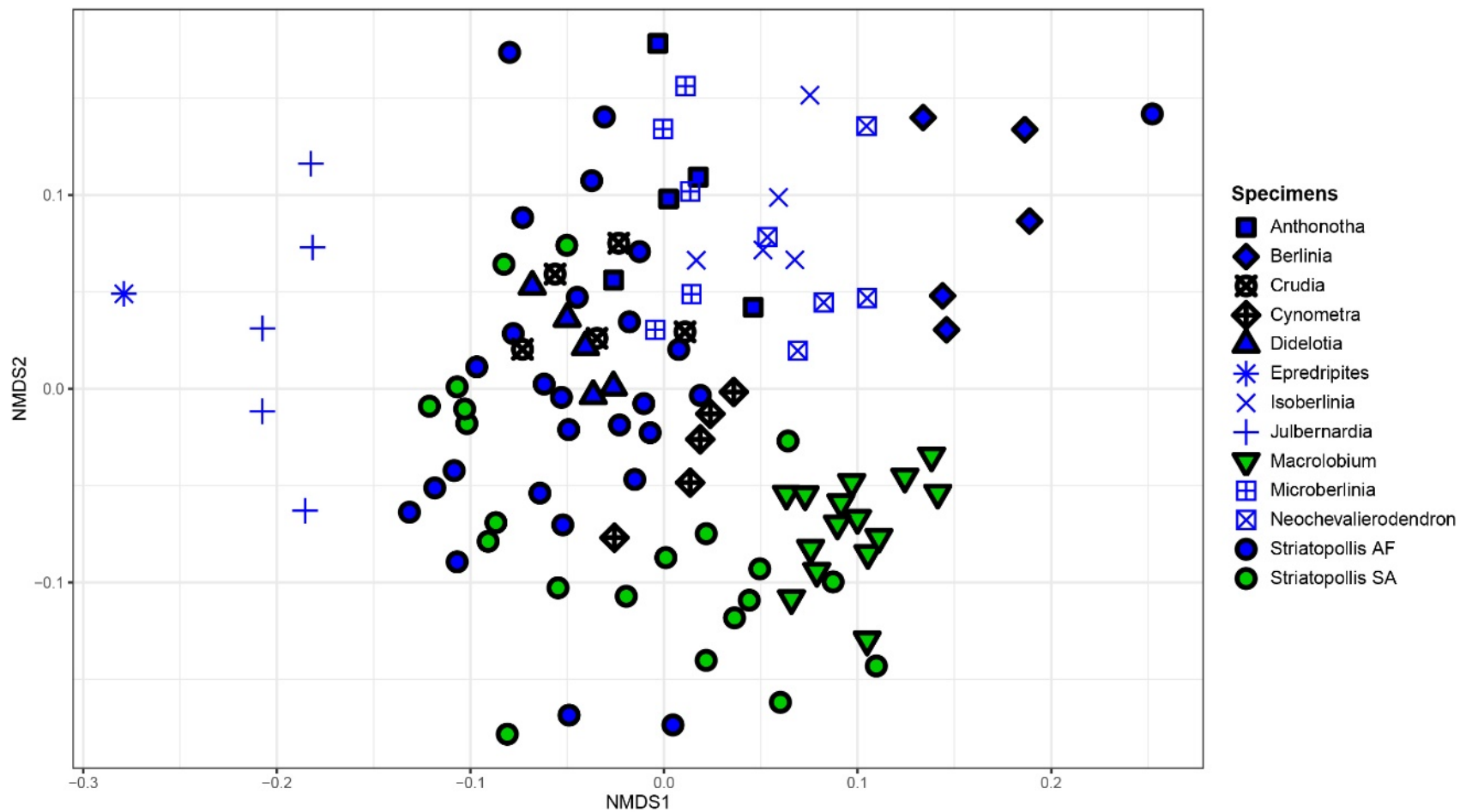




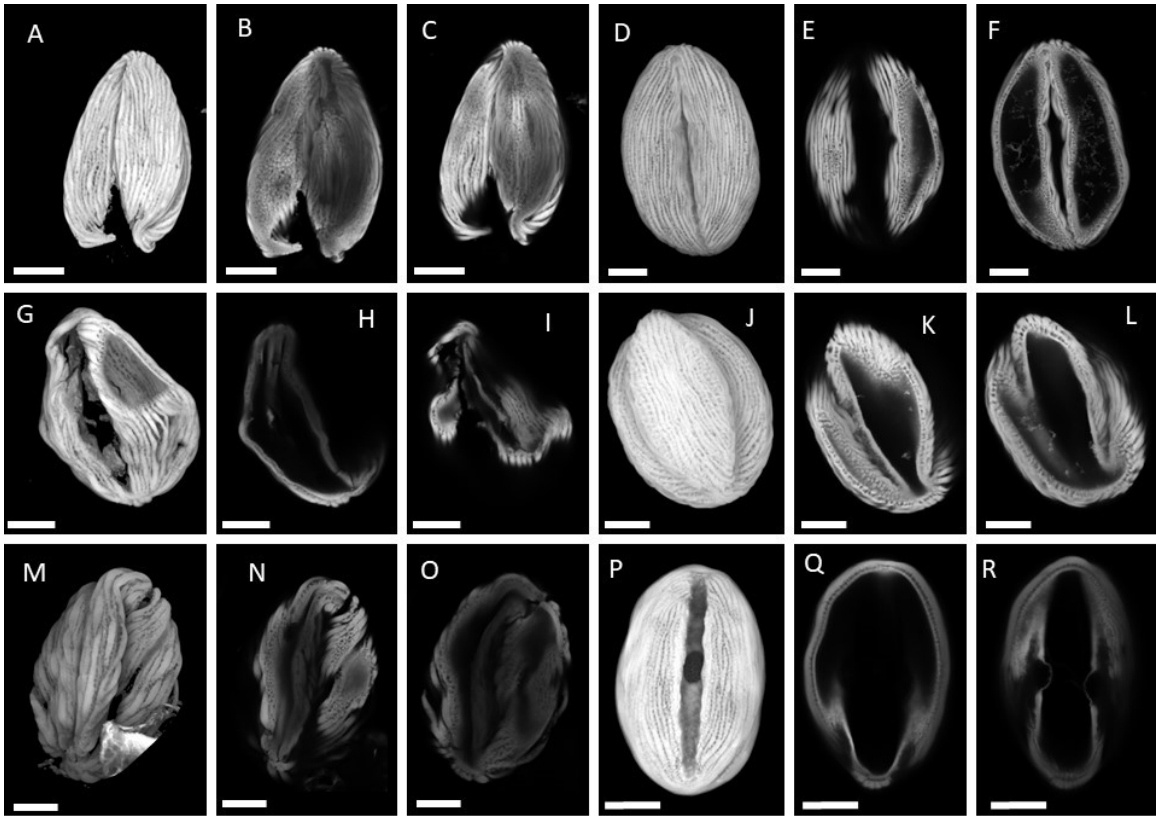
**Fig. S7.** Comparison of images of *Neothevalierodendron* (A-F) with *Anthonotha* (G-L), *Isoberlinia* (M-R), *Crudia* (S-X), and *Macrolobium* (Y-Ad). The images were used as inputs for the three CNN models.



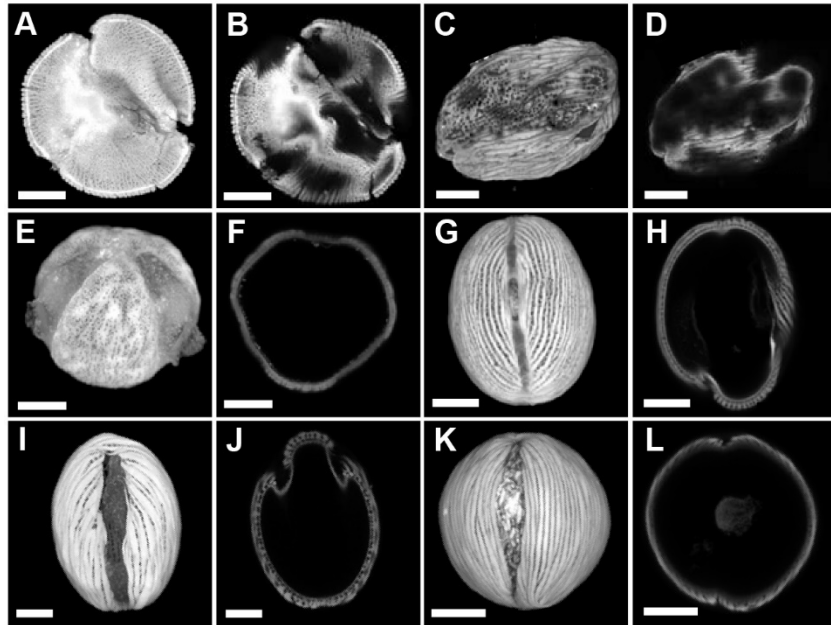
**Fig. S8.** Scatterplot comparing the relationship between the age of the fossil specimen and the FM classification scores for specimens classified as: *Crudia*(A), *Macrolobium* (B), *Neochevalierodendron* (C), *Berlinia* (D), and *Anthonotha* (E).



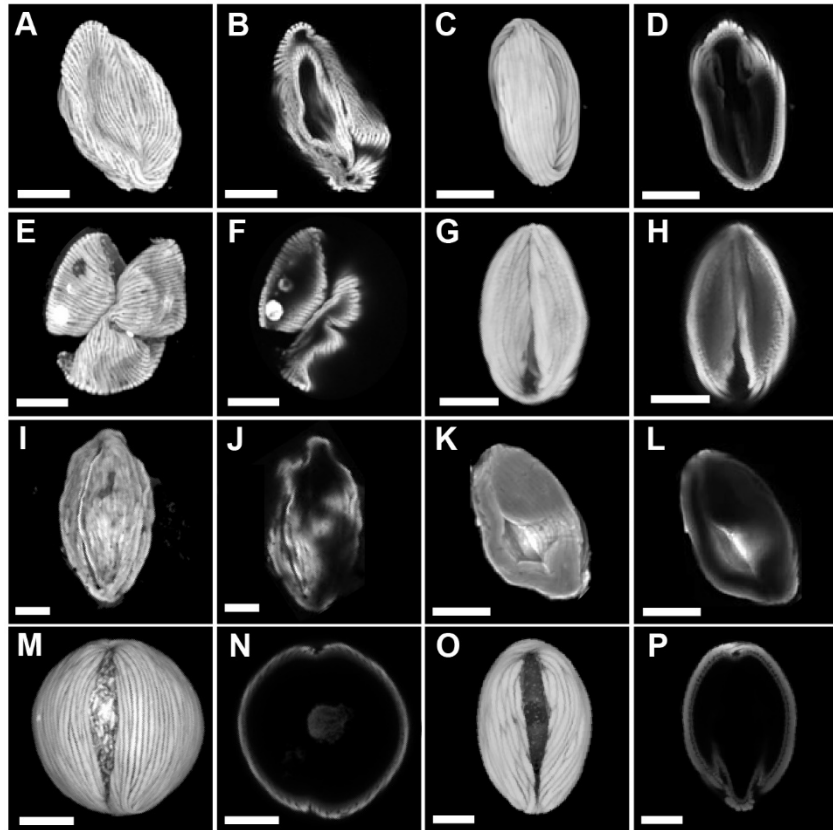
**Fig. S9.** Non-metric multidimensional scaling ordinations for morphological measurements of *S. catatumbus* and pollen of extant genera of Amherstieae. K=2, non-metric fit:  $R^2=0.957$ , stress=0.2. Shapes represent different genera. Colors indicate geographic regions: Africa (blue), tropical America (green), and pantropical (white).



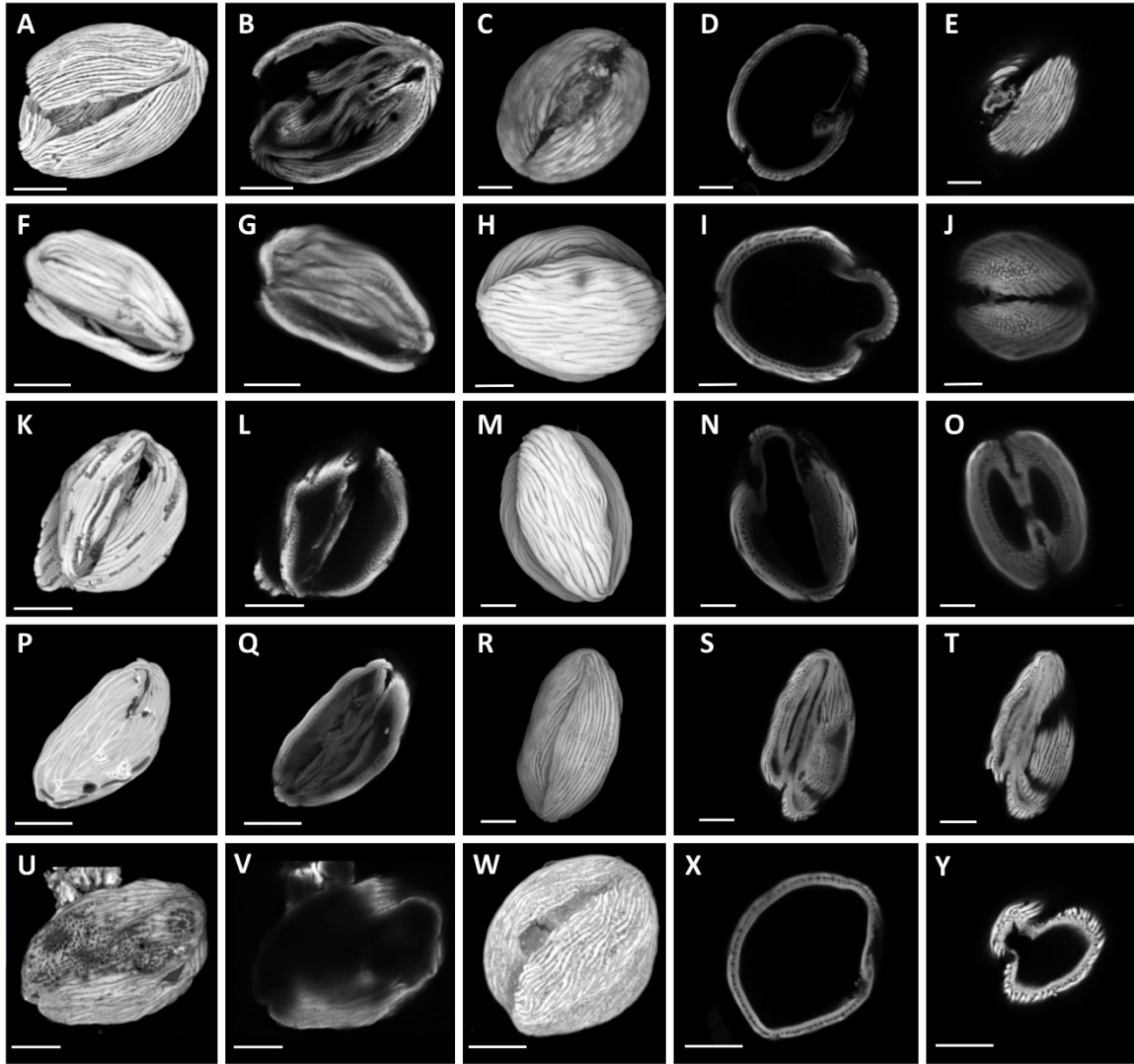
**Fig. S10.** African fossil specimens of *Striatopollis catatumbus* compared with modern specimens. Fossils: Thanetian: 024.*Striatopollis* AF (A-C); Ypresian: 03.*Striatopollis* AF (G-I), 07.*Striatopollis* AF (M-O). Modern specimens of *Neochevalierodendron* (D-F), *Berlinia* (J-L), *Cynometra* (P-R). Scale bars: 10  $\mu$ m.



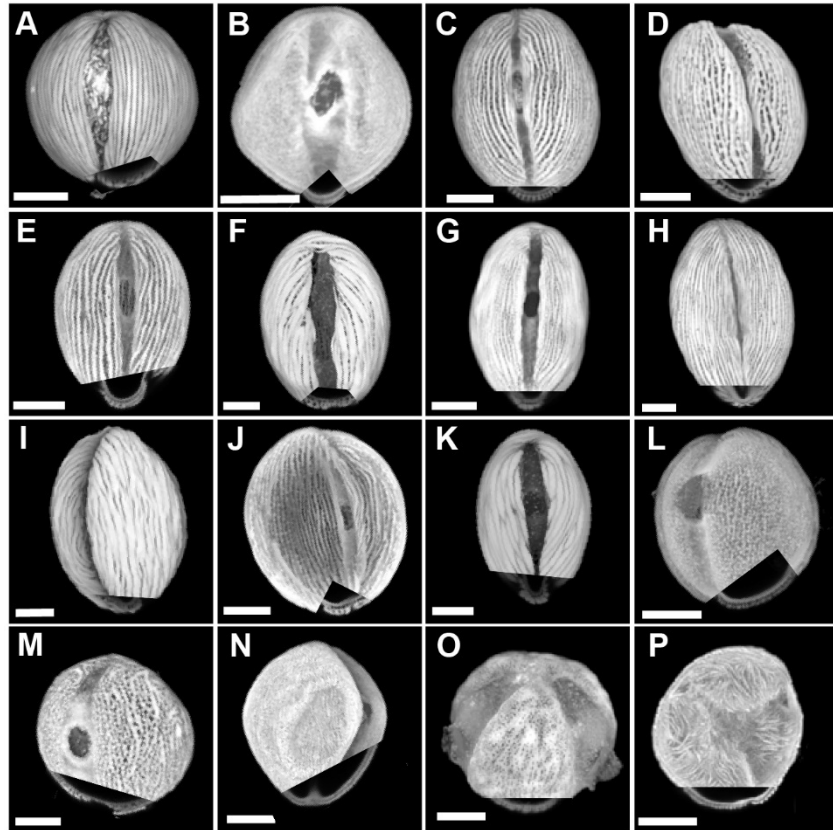
**Fig. S11.** African and South American fossil specimens of *Striatopollis catatumbus* compared with modern specimens. Fossils: Ypresian: 01.Striatopollis AF (A, B); PETM: 044.Striatopollis SA (C, D). Modern specimens of *Julbernardia* (E, F), *Anthonotha* (G, H), *Isoberlinia* (I, J), *Crudia* (K, L). Scale bars: 10  $\mu$ m.



**Fig. S12.** South American fossil specimens of *S. catatumbus* compared with modern specimens. Fossils: Tortonian: 029.Striatopollis SA (A, B), 037.Striatopollis SA (C, D); Serravallian: 030.Striatopollis SA (E, F), 032.Striatopollis SA (G, H); PETM: 031.Striatopollis SA (I,J); Langhian: 041.Striatopollis SA (K, L). Modern specimens of *Crudia* (M, N), *Macrolobium* (O, P). Scale bars: 10  $\mu$ m.

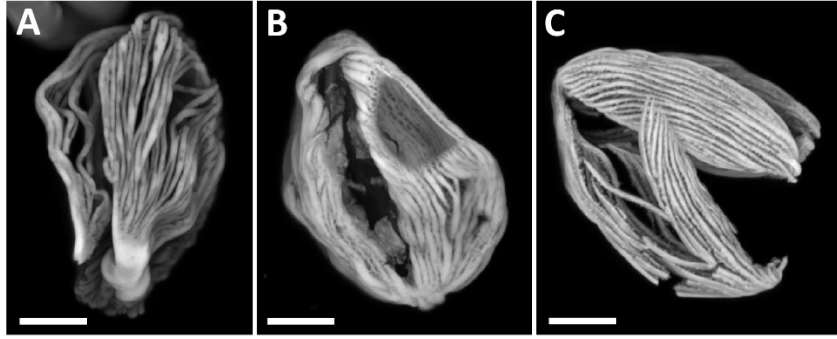


**Fig. S13.** South American fossil specimens of *S. catatumbus* compared with modern African specimens. Fossils: PETM: 044.Striatopollis SA (UV); Burdigalian: 028.Striatopollis SA (A, B), 034.Striatopollis SA (K, L), 040.Striatopollis SA (P, Q); Serravallian: 033.Striatopollis SA (F, G). Modern specimens of *Anthonotha* (C-E), *Berlinia* (H-J, M-O), *Neochevalierodendron* (R-T), and *Julbernardia* (W-Y). Scale bars: 10  $\mu$ m.



**Fig. S14.** External and internal morphology of specimens from the 16 extant genera of Amherstieae selected: *Crudia* (A), *Aphanocalyx* (B), *Anthonotha* (C), *Microberlinia* (D), *Didelotia* (E), *Isoberlinia* (F), *Cynometra* (G), *Neochevalierodendron* (H), *Berlinia* (I), *Gilbertiodendron* (J), *Macrobium* (K), *Hymenostegia* (L), *Tetraberlinia* (M), *Bikinia* (N), *Julbernardia* (O), *Tamarindus* (P). Scale bars: 10  $\mu$ m.





**Fig. S15.** Side-by-side comparison of *Ephedripites* sp. (A) and *Striatopollis catatumbus* (B, C). Scale bars: 10  $\mu$ m.

**Table S1.** Fossil identifications from the three classification models. “Specimen ID” refers to the specimen label given to each specimen in Dataset S4. “Specimen name” refers to the expert identification given in the literature. Background color indicates the biogeography of the extant genus: African (blue), Neotropical (green), and pantropical (white). Numbers in the brackets indicate the classification confidence scores for the CNN identification label.

Specimen ID	Specimen Name	Age specimens	MPM	MSM	FM
01.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Hymenostegia</i> (0.284)	<i>Julbernardia</i> (0.998)	<i>Julbernardia</i> (0.496)
02.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Crudia</i> (0.548)	<i>Crudia</i> (0.971)	<i>Crudia</i> (0.727)
03.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Cynometra</i> (0.519)	<i>Cynometra</i> (0.961)	<i>Neochevalierodendron</i> (0.495)
04.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Berlinia</i> (0.483)	<i>Berlinia</i> (0.899)	<i>Berlinia</i> (0.546)
05.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Isoberlinia</i> (0.749)	<i>Berlinia</i> (0.980)	<i>Berlinia</i> (0.500)
06.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Anthonotha</i> (0.990)	<i>Didelotia</i> (0.840)	<i>Anthonotha</i> (0.997)
07.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Cynometra</i> (0.670)	<i>Berlinia</i> (0.707)	<i>Neochevalierodendron</i> (0.493)
08.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Crudia</i> (0.496)	<i>Crudia</i> (0.847)	<i>Crudia</i> (0.844)
09.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Crudia</i> (0.880)	<i>Isoberlinia</i> (0.811)	<i>Anthonotha</i> (0.596)
010.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Berlinia</i> (0.912)	<i>Julbernardia</i> (0.942)	<i>Berlinia</i> (0.998)
011.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Anthonotha</i> (0.746)	<i>Didelotia</i> (0.967)	<i>Crudia</i> (0.524)
012.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Didelotia</i> (0.453)	<i>Crudia</i> (0.984)	<i>Crudia</i> (0.787)
013.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Anthonotha</i> (0.768)	<i>Anthonotha</i> (0.920)	<i>Anthonotha</i> (0.984)
014.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Crudia</i> (0.523)	<i>Crudia</i> (0.543)	<i>Crudia</i> (0.527)
015.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Anthonotha</i> (0.854)	<i>Microberlinia</i> (0.952)	<i>Microberlinia</i> (0.535)
016.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Isoberlinia</i> (0.458)	<i>Berlinia</i> (0.958)	<i>Berlinia</i> (0.516)
017.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Didelotia</i> (0.457)	<i>Crudia</i> (0.941)	<i>Crudia</i> (0.516)
018.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Crudia</i> (0.382)	<i>Crudia</i> (0.909)	<i>Crudia</i> (0.563)
019.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Crudia</i> (0.528)	<i>Crudia</i> (0.905)	<i>Crudia</i> (0.741)
020.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Didelotia</i> (0.470)	<i>Crudia</i> (0.965)	<i>Crudia</i> (0.510)
021.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Crudia</i> (0.955)	<i>Neochevalierodendron</i> (0.826)	<i>Crudia</i> (0.925)
022.Striatopollis AF	<i>Striatopollis catatumbus</i>	Ypresian	<i>Crudia</i> (0.456)	<i>Cynometra</i> (0.909)	<i>Crudia</i> (0.507)

023.Striatopollis AF	<i>Striatopollis catatumbus</i>	Thanetian	<i>Crudia</i> (0.980)	<i>Crudia</i> (1.000)	<i>Crudia</i> (1.000)
024.Striatopollis AF	<i>Striatopollis catatumbus</i>	Thanetian	<i>Berlinia</i> (0.417)	<i>Berlinia</i> (0.676)	<i>Neochevalierodendron</i> (0.501)
025.Striatopollis AF	<i>Striatopollis catatumbus</i>	Thanetian	<i>Crudia</i> (0.746)	<i>Crudia</i> (0.940)	<i>Crudia</i> (0.722)
026.Striatopollis AF	<i>Striatopollis catatumbus</i>	Thanetian	<i>Crudia</i> (0.936)	<i>Crudia</i> (0.997)	<i>Crudia</i> (0.994)
027.Striatopollis AF	<i>Striatopollis catatumbus</i>	Thanetian	<i>Crudia</i> (0.969)	<i>Crudia</i> (0.933)	<i>Crudia</i> (0.998)
028.Striatopollis SA	<i>Striatopollis catatumbus</i>	Burdigalian	<i>Didelotia</i> (0.906)	<i>Anthonotha</i> (0.738)	<i>Anthonotha</i> (0.672)
029.Striatopollis SA	<i>Striatopollis catatumbus</i>	Tortonian	<i>Didelotia</i> (0.598)	<i>Crudia</i> (0.784)	<i>Crudia</i> (0.491)
030.Striatopollis SA	<i>Striatopollis catatumbus</i>	Serravallian	<i>Crudia</i> (0.940)	<i>Crudia</i> (0.981)	<i>Crudia</i> (0.993)
031.Striatopollis SA	<i>Striatopollis catatumbus</i>	PETM	<i>Crudia</i> (0.926)	<i>Crudia</i> (0.797)	<i>Crudia</i> (0.986)
032.Striatopollis SA	<i>Striatopollis "crassitectatus"</i>	Serravallian	<i>Macrolobium</i> (0.986)	<i>Macrolobium</i> (0.997)	<i>Macrolobium</i> (0.575)
033.Striatopollis SA	<i>Striatopollis catatumbus</i>	Serravallian	<i>Cynometra</i> (0.762)	<i>Macrolobium</i> (0.831)	<i>Berlinia</i> (0.609)
034.Striatopollis SA	<i>Striatopollis catatumbus</i>	Burdigalian	<i>Isoberlinia</i> (0.741)	<i>Berlinia</i> (1.000)	<i>Berlinia</i> (0.848)
035.Striatopollis SA	<i>Striatopollis catatumbus</i>	Serravallian	<i>Crudia</i> (0.474)	<i>Crudia</i> (0.968)	<i>Crudia</i> (0.924)
036.Striatopollis SA	<i>Striatopollis "crassitectatus"</i>	Tortonian	<i>Macrolobium</i> (0.992)	<i>Macrolobium</i> (0.991)	<i>Macrolobium</i> (0.980)
037.Striatopollis SA	<i>Striatopollis "crassitectatus"</i>	Tortonian	<i>Macrolobium</i> (1.000)	<i>Macrolobium</i> (1.000)	<i>Macrolobium</i> (1.000)
038.Striatopollis SA	<i>Striatopollis "crassitectatus"</i>	Tortonian	<i>Macrolobium</i> (1.000)	<i>Macrolobium</i> (0.994)	<i>Macrolobium</i> (1.000)
039.Striatopollis SA	<i>Striatopollis "crassitectatus"</i>	Serravallian	<i>Macrolobium</i> (0.765)	<i>Macrolobium</i> (0.979)	<i>Macrolobium</i> (0.628)
040.Striatopollis SA	<i>Striatopollis "pseudocrassitectatus"</i>	Burdigalian	<i>Isoberlinia</i> (0.308)	<i>Cynometra</i> (0.900)	<i>Neochevalierodendron</i> (0.494)
041.Striatopollis SA	<i>Striatopollis "crassitectatus"</i>	Langhian	<i>Crudia</i> (0.535)	<i>Macrolobium</i> (0.884)	<i>Macrolobium</i> (0.498)
042.Striatopollis SA	<i>Striatopollis catatumbus</i>	Langhian	<i>Crudia</i> (0.838)	<i>Crudia</i> (0.769)	<i>Crudia</i> (0.841)
043.Striatopollis SA	<i>Striatopollis catatumbus</i>	PETM	<i>Crudia</i> (0.581)	<i>Crudia</i> (0.926)	<i>Crudia</i> (0.853)
044.Striatopollis SA	<i>Striatopollis catatumbus</i>	PETM	<i>Crudia</i> (0.604)	<i>Isoberlinia</i> (0.723)	<i>Anthonotha</i> (0.497)
045.Striatopollis SA	<i>Striatopollis catatumbus</i>	PETM	<i>Anthonotha</i> (0.604)	<i>Crudia</i> (0.440)	<i>Crudia</i> (0.459)
046.Striatopollis SA	<i>Striatopollis catatumbus</i>	PETM	<i>Julbernardia</i> (0.407)	<i>Crudia</i> (0.988)	<i>Crudia</i> (0.674)
047.Striatopollis SA	<i>Striatopollis catatumbus</i>	PETM	<i>Crudia</i> (0.873)	<i>Crudia</i> (0.951)	<i>Crudia</i> (0.904)
048.Striatopollis SA	<i>Striatopollis catatumbus</i>	PETM	<i>Microberlinia</i> (0.512)	<i>Crudia</i> (0.877)	<i>Crudia</i> (0.517)

**Table S2.** Table of all FM classification confidence scores for each fossil *Striatopollis* specimen. “Specimen ID” refers to the specimen label given to each specimen in Dataset S4.

Specimen ID	Specimens Age	Predicted label probability															
		<i>Anthoantha</i>	<i>Aphanocalyx</i>	<i>Berlinia</i>	<i>Bikinia</i>	<i>Crudia</i>	<i>Cynometra</i>	<i>Didelotia</i>	<i>Gilbertiodendron</i>	<i>Hymenostegia</i>	<i>Isoberlinia</i>	<i>Julbernardia</i>	<i>Macrolobium</i>	<i>Microberlinia</i>	<i>Neochevalierodendron</i>	<i>Tamarindus</i>	<i>Tetraberlinia</i>
01.Striatopollis AF	Ypresian	0.048	0.001	0.082	0.025	0.004	0.004	0	0.001	0.001	0.335	0.496	0.002	0	0	0	0.001
02.Striatopollis AF	Ypresian	0.271	0	0	0	0.727	0	0.002	0	0	0	0	0	0	0	0	0
03.Striatopollis AF	Ypresian	0	0	0.025	0	0	0.453	0	0.001	0	0.025	0	0	0	0.495	0	0
04.Striatopollis AF	Ypresian	0	0	0.546	0	0	0.448	0	0	0	0.006	0	0	0	0	0	0
05.Striatopollis AF	Ypresian	0	0	0.5	0	0	0.009	0	0	0	0.491	0	0	0	0	0	0
06.Striatopollis AF	Ypresian	0.997	0	0	0	0	0	0	0.002	0	0	0	0	0	0	0	0
07.Striatopollis AF	Ypresian	0	0	0.005	0	0.001	0.294	0	0	0	0.206	0	0.001	0	0.493	0	0
08.Striatopollis AF	Ypresian	0.006	0.004	0.002	0	0.844	0.118	0	0.001	0.005	0.002	0	0.013	0	0	0.003	0
09.Striatopollis AF	Ypresian	0.596	0	0	0	0.403	0	0.002	0	0	0	0	0	0	0	0	0
010.Striatopollis AF	Ypresian	0	0	0.998	0	0	0.001	0	0	0	0.001	0	0	0	0	0	0
011.Striatopollis AF	Ypresian	0.466	0	0	0	0.524	0	0.008	0	0	0	0	0	0	0.001	0	0
012.Striatopollis AF	Ypresian	0.006	0	0	0	0.787	0	0.184	0.017	0	0	0.006	0	0	0	0	0
013.Striatopollis AF	Ypresian	0.984	0	0	0	0.011	0	0	0.001	0	0.003	0	0	0	0	0	0.001

014.Striatopollis AF	Ypresian	0.45	0	0.001	0	0.527	0.003	0.001	0.001	0	0.013	0	0	0	0.001	0	0
015.Striatopollis AF	Ypresian	0.447	0	0	0	0.002	0	0.007	0.008	0	0	0	0	0.535	0	0	0
016.Striatopollis AF	Ypresian	0	0.002	0.516	0	0	0.006	0	0	0	0.474	0	0	0.001	0	0	0.001
017.Striatopollis AF	Ypresian	0.001	0	0	0	0.516	0	0.453	0.017	0	0.001	0	0	0.004	0	0.009	0
018.Striatopollis AF	Ypresian	0	0.178	0	0	0.563	0.15	0.002	0.001	0.086	0	0.001	0	0.001	0	0.018	0
019.Striatopollis AF	Ypresian	0.003	0	0	0	0.741	0	0.233	0.021	0	0	0	0	0	0.002	0	0
020.Striatopollis AF	Ypresian	0.06	0	0	0	0.51	0	0.337	0.007	0	0	0.085	0	0	0	0	0
021.Striatopollis AF	Ypresian	0.014	0	0.008	0	0.925	0.006	0	0	0	0.002	0	0	0	0.045	0	0
022.Striatopollis AF	Ypresian	0.001	0	0.001	0	0.507	0.056	0	0	0	0.339	0.086	0.009	0	0	0	0
023.Striatopollis AF	Thanetian	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
024.Striatopollis AF	Thanetian	0	0	0.487	0	0.006	0	0	0	0	0.006	0	0	0	0.501	0	0
025.Striatopollis AF	Thanetian	0	0	0	0	0.722	0.266	0	0	0.005	0	0.001	0.005	0	0	0	0
026.Striatopollis AF	Thanetian	0	0	0	0	0.994	0	0.005	0	0.001	0	0	0	0	0	0	0
027.Striatopollis AF	Thanetian	0	0	0	0	0.998	0	0	0	0	0	0	0	0	0	0	0
028.Striatopollis SA	Burdigalian	0.672	0	0	0	0.003	0	0.321	0.002	0	0	0	0	0	0.003	0	0
029.Striatopollis SA	Tortonian	0.477	0	0	0	0.491	0	0.028	0	0	0	0	0	0	0.002	0	0
030.Striatopollis SA	Serravallian	0.007	0	0	0	0.993	0	0	0	0	0	0	0	0	0	0	0
031.Striatopollis SA	PETM	0.003	0	0.001	0	0.986	0.001	0	0	0	0.004	0.003	0	0	0.001	0	0
032.Striatopollis SA	Serravallian	0	0	0.017	0	0	0.408	0	0	0	0	0	0.575	0	0	0	0
033.Striatopollis SA	Serravallian	0	0	0.609	0	0	0.391	0	0	0	0	0	0	0	0	0	0
034.Striatopollis SA	Burdigalian	0	0	0.848	0	0	0.126	0	0	0	0.026	0	0	0	0	0	0

035.Striatopollis SA	Serravallian	0.05	0	0	0	0.924	0.001	0	0	0	0.002	0.007	0.005	0	0	0.01	0
036.Striatopollis SA	Tortonian	0	0	0.02	0	0	0	0	0	0	0	0	0.98	0	0	0	0
037.Striatopollis SA	Tortonian	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
038.Striatopollis SA	Tortonian	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
039.Striatopollis SA	Serravallian	0	0	0.372	0	0	0	0	0	0	0	0	0.628	0	0	0	0
040.Striatopollis SA	Burdigalian	0.001	0	0.465	0	0	0.038	0	0	0	0.001	0	0.001	0	0.494	0	0
041.Striatopollis SA	Langhian	0.026	0	0.085	0	0.268	0.027	0	0	0	0.082	0.015	0.498	0	0	0	0
042.Striatopollis SA	Langhian	0.006	0	0.004	0	0.841	0.08	0	0	0	0.032	0.036	0	0	0	0	0
043.Striatopollis SA	PETM	0.001	0	0	0	0.853	0	0	0	0	0	0.146	0	0	0	0	0
044.Striatopollis SA	PETM	0.497	0	0.002	0	0.05	0	0	0	0	0.003	0.447	0	0	0	0	0
045.Striatopollis SA	PETM	0.053	0	0.015	0	0.459	0.325	0.006	0.001	0	0.005	0.053	0	0	0.083	0	0
046.Striatopollis SA	PETM	0.001	0.039	0.006	0	0.674	0.11	0	0	0	0.015	0.154	0	0	0	0	0
047.Striatopollis SA	PETM	0.001	0	0	0	0.904	0.001	0.001	0	0	0.002	0.091	0	0	0	0	0
048.Striatopollis SA	PETM	0.003	0	0.399	0	0.517	0	0.005	0	0	0.016	0	0	0.059	0	0	0

---

**Table S3.** Comparison of CNN FM classification confidence scores (cs), NMDS similarity distances (sim), and expert palynological assessment for the 49 fossil *Striatopollis* and *Ephedripites* specimens. “Specimen ID” refers to the specimen label given to each specimen in Dataset S4.

Specimen ID	Location	Age specimens	FM-CNN (cs)	NMDS (sim)	Palynologist assessment	Fossil morphology
01.Striatopollis AF	Africa	Ypresian	<i>Julbernardia</i> (0.496) <i>Isoberlinia</i> (0.335)	<i>Didelotia</i> (0.959) <i>Crudia</i> (0.950)	<i>Crudia</i>	Striate, mushroom shape striae, reticulate tectum. Fossil in polar view, broken, and very flat, give the impression that the ornamentation is reticulate-striae.
02.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.727)	<i>Didelotia</i> (0.954) <i>Cynometra</i> (0.953) <i>Crudia</i> (0.936)	<i>Crudia/Didelotia</i>	Striae, reticulate tectum, Striae mushroom- shaped and clavate as <i>Crudia</i> and <i>Didelotia</i> . Morphology similar to at least two genera.
03.Striatopollis AF	Africa	Ypresian	<i>Neochevalierodendron</i> (0.495) <i>Cynometra</i> (0.453)	<i>Crudia</i> (0.946) <i>Didelotia</i> (0.944) <i>Cynometra</i> (0.941) <i>Microberlinia</i> (0.924)	<i>Crudia</i> or an African genera	Striae, reticulate tectum, striae are non-clavate shaped and more similar to <i>Crudia</i> , but striation pattern similar to <i>Crudia</i> . Striae ticker than <i>Crudia</i> . <i>Neochevalierodendron</i> , <i>Didelotia</i> , <i>Microberlinia</i> have clavate striae.
04.Striatopollis AF	Africa	Ypresian	<i>Berlinia</i> (0.546) <i>Cynometra</i> (0.448)	<i>Berlinia</i> (0.887) <i>Neochevalierodendron</i> (0.810)	<i>Berlinia</i>	Striae, tectum foveolate perforate. Striae shape is a mix of clavate to baculate.
05.Striatopollis AF	Africa	Ypresian	<i>Berlinia</i> (0.500) <i>Isoberlinia</i> (0.491)	<i>Didelotia</i> (0.906) <i>Cynometra</i> (0.922) <i>Crudia</i> (0.882)	<i>Berlinia/Crudia</i>	Striae, tectum reticulate, striae are clavate to mushroom-shaped, thick striae. Striation pattern similar to <i>Crudia</i> .
06.Striatopollis AF	Africa	Ypresian	<i>Anthonotha</i> (0.997)	<i>Microberlinia</i> (0.934) <i>Anthonotha</i> (0.933) <i>Crudia</i> (0.929)	<i>Anthonotha</i>	Striate, tectum reticulate. Striae are clavate similar to <i>Anthonotha</i> . Striation pattern similar to <i>Microberlinia</i> .
07.Striatopollis AF	Africa	Ypresian	<i>Neochevalierodendron</i> (0.493) <i>Cynometra</i> (0.294)	<i>Cynometra</i> (0.850) <i>Macrolobium</i> (0.822) <i>Didelotia</i> (0.809) <i>Crudia</i> (0.787)	<i>Crudia</i> or an African genera	Striate, tectum reticulate. Striae are clavate to mushroom shape. Striae thick as <i>Cynometra</i> , but striation pattern similar to <i>Crudia</i> .

08.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.844)	<i>Cynometra</i> (0.956) <i>Didelotia</i> (0.925) <i>Crudia</i> (0.904)	<i>Crudia</i>	Striate, tectum foveolate-perforate. Striae are mushroom-shaped. Striation pattern is not clear for preservation issues.
09.Striatopollis AF	Africa	Ypresian	<i>Anthonotha</i> (0.596) <i>Crudia</i> (0.403)	<i>Didelotia</i> (0.941) <i>Crudia</i> (0.928)	<i>Anthonotha</i>	Striate, tectum reticulate. Striae are clavate. Striae similar to <i>Anthonotha</i> .
010.Striatopollis AF	Africa	Ypresian	<i>Berlinia</i> (0.998)	<i>Cynometra</i> (0.961)  <i>Didelotia</i> (0.942) <i>Crudia</i> (0.923)	<i>Berlinia</i>	Striate, tectum foveolate-perforate. Striae are mushroom shaped to clavate. Striation pattern not very clear for preservation issues, but seems similar to <i>Berlinia</i> .
011.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.524) <i>Anthonotha</i> (0.466)	<i>Crudia</i> (0.962) <i>Didelotia</i> (0.962)  <i>Microberlinia</i> (0.930) <i>Anthonotha</i> (0.924) <i>Cynometra</i> (0.920)	<i>Anthonotha</i>	Striate, tectum reticulate, striae are clavate. Striation pattern similar to <i>Anthonotha</i> . Pollen is broken and incomplete.
012.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.787)	<i>Didelotia</i> (0.954) <i>Cynometra</i> (0.949) <i>Crudia</i> (0.930)	<i>Crudia</i>	Striate, tectum perforate. Striae are mushroom shaped to clavate. Striation similar to <i>Crudia</i> .
013.Striatopollis AF	Africa	Ypresian	<i>Anthonotha</i> (0.984)	<i>Crudia</i> (0.953)  <i>Microberlinia</i> (0.946) <i>Anthonotha</i> (0.945) <i>Didelotia</i> (0.937) <i>Isoberlinia</i> (0.926)	<i>Anthonotha</i>	Striate, tectum reticulate, striae are clavate. Pollen is broken and incomplete.
014.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.527) <i>Anthonotha</i> (0.45)	<i>Macrolobium</i> (0.860) <i>Cynometra</i> (0.857)	<i>Crudia</i>	Striate, tectum reticulate-foveolate. Striae are mushroom-shaped. Striation pattern similar to <i>Crudia</i> . Pollen in polar view.
015.Striatopollis AF	Africa	Ypresian	<i>Microberlinia</i> (0.535) <i>Anthonotha</i> (0.447)	<i>Microberlinia</i> (0.876) <i>Anthonotha</i> (0.876)	<i>Microberlinia</i>	Striate, tectum reticulate as <i>Microberlinia</i> . Striae are clavate, striation pattern seems similar to



				<i>Crudia</i> (0.858) <i>Didelotia</i> (0.843) <i>Isoberlinia</i> (0.838)		<i>Microberlinia</i> but height of striae similar to <i>Anthonotha</i> .
016.Striatopollis AF	Africa	Ypresian	<i>Berlinia</i> (0.516) <i>Isoberlinia</i> (0.474)	<i>Microberlinia</i> (0.930) <i>Anthonotha</i> (0.926) <i>Crudia</i> (0.898) <i>Isoberlinia</i> (0.895)	<i>Berlinia/Isoberlinia</i>	Striate, tectum reticulate as <i>Isoberlinia</i> . Striae are clavate and striation similar to <i>Berlinia</i> .
017.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.516) <i>Didelotia</i> (0.453)	<i>Didelotia</i> (0.964) <i>Crudia</i> (0.945) <i>Cynometra</i> (0.910)	<i>Crudia</i>	Striate, tectum reticulate. Striae mushroom shaped.
018.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.563) <i>Aphanocalyx</i> (0.178)	<i>Julbernardia</i> (0.880) <i>Didelotia</i> (0.875) <i>Crudia</i> (0.855) <i>Cynometra</i> (0.850)	<i>Crudia</i>	Striate, striation pattern similar to <i>Crudia</i> . Internal arrangement of the wall is not clear due to preservation.
019.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.741)	<i>Didelotia</i> (0.965) <i>Crudia</i> (0.942) <i>Cynometra</i> (0.920)	<i>Crudia</i>	Striate, tectum reticulate, striae are mushroom-shaped. Striation similar to <i>Crudia</i> .
020.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.510) <i>Didelotia</i> (0.337)	<i>Didelotia</i> (0.920) <i>Cynometra</i> (0.916) <i>Crudia</i> (0.896)	<i>Crudia</i>	Striate, tectum reticulate, striae are mushroom shaped.
021.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.925)	<i>Didelotia</i> (0.954) <i>Crudia</i> (0.929) <i>Cynometra</i> (0.928)	<i>Crudia</i>	Striate, tectum foveolate-perforate. Striae are mushroom-shaped.
022.Striatopollis AF	Africa	Ypresian	<i>Crudia</i> (0.507) <i>Isoberlinia</i> (0.339)	<i>Cynometra</i> (0.964) <i>Didelotia</i> (0.930) <i>Crudia</i> (0.924) <i>Neochevalierodendron</i> (0.902) <i>Microberlinia</i> (0.900)	Amherstieae	Striate. Ornamentation of the tectum and internal arrangements of the wall are not clear due to preservation issues.
023.Striatopollis AF	Africa	Thanetian	<i>Crudia</i> (1.000)	<i>Didelotia</i> (0.893) <i>Julbernardia</i> (0.879) <i>Crudia</i> (0.873) <i>Cynometra</i> (0.864)	<i>Crudia</i>	Striate, tectum perforate. Shape of the striae are not clear due to preservation issues.

024.Striatopollis AF	Africa	Thanetian	<i>Neochevalierodendron</i> (0.501) <i>Berlinia</i> (0.487)	<i>Didelotia</i> (0.967) <i>Crudia</i> (0.965) <i>Microberlinia</i> (0.919) <i>Anthonotha</i> (0.918)	<i>Neochevalierodendron/Berlinia</i>	Striate, tectum reticulate, striae are clavate. Striation pattern similar to several African genera.
025.Striatopollis AF	Africa	Thanetian	<i>Crudia</i> (0.722)	<i>Crudia</i> (0.934) <i>Didelotia</i> (0.927) <i>Microberlinia</i> (0.906) <i>Anthonotha</i> (0.906)	<i>Crudia</i>	Striate, tectum seems reticulate, and striae seems mushroom-shaped. Internal arrangements of the wall are not clear due to preservation.
026.Striatopollis AF	Africa	Thanetian	<i>Crudia</i> (0.994)	<i>Didelotia</i> (0.906) <i>Crudia</i> (0.886)	<i>Crudia</i>	Striate, tectum perforate. Shape of the striae are not clear due to preservation issues
027.Striatopollis AF	Africa	Thanetian	<i>Crudia</i> (0.998)	<i>Didelotia</i> (0.870) <i>Cynometra</i> (0.866) <i>Crudia</i> (0.848) <i>Julbernardia</i> (0.847)	<i>Crudia</i>	Striate, tectum foveolate-perforate. Shape of the striae are mushroom-shaped. Internal arrangements of the wall are not clear due to preservation issues
028.Striatopollis SA	South America	Burdigalian	<i>Anthonotha</i> (0.672)	<i>Didelotia</i> (0.942) <i>Crudia</i> (0.941) <i>Microberlinia</i> (0.895) <i>Anthonotha</i> (0.894)	<i>Crudia/Anthonotha</i>	Striate, tectum reticulate. Striae clavate to mushroom-shaped.
029.Striatopollis SA	South America	Tortonian	<i>Crudia</i> (0.491) <i>Anthonotha</i> (0.477)	<i>Cynometra</i> (0.918) <i>Didelotia</i> (0.868) <i>Crudia</i> (0.847)	<i>Crudia</i>	Striate, tectum reticulate, striae clavate to mushroom-shaped. Striation similar to <i>Crudia</i> .
030.Striatopollis SA	South America	Serravallian	<i>Crudia</i> (0.993)	<i>Crudia</i> (0.954) <i>Didelotia</i> (0.945) <i>Anthonotha</i> (0.924) <i>Microberlinia</i> (0.923)	<i>Crudia</i>	Striate, tectum reticulate-foveolate, striae mushroom-shaped. Striation similar to <i>Crudia</i> .
031.Striatopollis SA	South America	PETM	<i>Crudia</i> (0.986)	<i>Didelotia</i> (0.887) <i>Cynometra</i> (0.884) <i>Crudia</i> (0.864) <i>Julbernardia</i> (0.843)	<i>Crudia</i>	Striate, ornamentation of the tectum is not clear. Internal arrangement of the wall is not clear due to preservation. Striation similar to <i>Crudia</i> .

032.Striatopollis SA	South America	Serravallian	<i>Macrolobium</i> (0.575) <i>Cynometra</i> (0.408)	<i>Cynometra</i> (0.948) <i>Macrolobium</i> (0.920)	<i>Macrolobium</i>	Striate, tectum perforate. Striae are rectangular. Striation similar to <i>Macrolobium</i> .
033.Striatopollis SA	South America	Serravallian	<i>Berlinia</i> (0.609)	<i>Macrolobium</i> (0.930) <i>Cynometra</i> (0.912)	<i>Macrolobium</i>	Striate, tectum perforate. Striae are rectangular. Striation similar to <i>Macrolobium</i> .
034.Striatopollis SA	South America	Burdigalian	<i>Berlinia</i> (0.848)	<i>Cynometra</i> (0.939) <i>Macrolobium</i> (0.899)	<i>Macrolobium</i>	Striate, tectum perforate. Striae are rectangular. Striation similar to <i>Macrolobium</i> .
035.Striatopollis SA	South America	Serravallian	<i>Crudia</i> (0.924)	<i>Cynometra</i> (0.943) <i>Macrolobium</i> (0.939) <i>Neochevalierodendron</i> (0.904)	<i>Crudia</i>	Striate, tectum reticulate. Shape of the striae are clavate to mushroom-shaped. Striation similar to <i>Crudia</i> .
036.Striatopollis SA	South America	Tortonian	<i>Macrolobium</i> (0.980)	<i>Macrolobium</i> (0.958)	<i>Macrolobium</i>	Striate, tectum psilate. Striae are rectangular. Striation similar to <i>Macrolobium</i> .
037.Striatopollis SA	South America	Tortonian	<i>Macrolobium</i> (1.000)	<i>Macrolobium</i> (0.923)	<i>Macrolobium</i>	Striate, tectum perforate. Striae are rectangular. Striation similar to <i>Macrolobium</i> .
038.Striatopollis SA	South America	Tortonian	<i>Macrolobium</i> (1.000)	<i>Macrolobium</i> (0.942) <i>Cynometra</i> (0.923)	<i>Macrolobium</i>	Striate, tectum psilate. Striae are rectangular. Striation similar to <i>Macrolobium</i> .
039.Striatopollis SA	South America	Serravallian	<i>Macrolobium</i> (0.628)	<i>Macrolobium</i> (0.920) <i>Cynometra</i> (0.907)	<i>Macrolobium</i>	Striate, tectum psilate. Striae are rectangular. Striation similar to <i>Macrolobium</i> .
040.Striatopollis SA	South America	Burdigalian	<i>Neochevalierodendron</i> (0.494) <i>Berlinia</i> (0.465)	<i>Macrolobium</i> (0.895) <i>Cynometra</i> (0.889) <i>Didelotia</i> (0.825)	<i>Macrolobium</i>	Striate, tectum perforate. Striae seems rectangular. Striation similar to <i>Macrolobium</i> . Preservation of the grain is not very good.
041.Striatopollis SA	South America	Langhian	<i>Macrolobium</i> (0.498) <i>Crudia</i> (0.268)	<i>Macrolobium</i> (0.899) <i>Cynometra</i> (0.860)	<i>Macrolobium</i>	Striate, tectum perforate. Striae seems rectangular. Internal arrangement of the wall is not clear due to preservation. Striation similar to <i>Macrolobium</i>
	South America	Langhian	<i>Crudia</i> (0.841)	<i>Cynometra</i> (0.826)	<i>Macrolobium</i>	

042.Striatopollis SA				<i>Didelotia</i> (0.795) <i>Macrolobium</i> (0.790)		Striate, tectum psilate. Striae are rectangular. Striation similar to <i>Macrolobium</i> . Preservation of the grain is not very good.
043.Striatopollis SA	South America	PETM	<i>Crudia</i> (0.853)	<i>Didelotia</i> (0.897) <i>Cynometra</i> (0.891) <i>Crudia</i> (0.874)	<i>Crudia</i> -like	Striate, tectum reticulate-foveolate. Internal arrangement of the wall is not clear due to degradation.
044.Striatopollis SA	South America	PETM	<i>Anthonotha</i> (0.497) <i>Julbernardia</i> (0.447)	<i>Cynometra</i> (0.902) <i>Didelotia</i> (0.874) <i>Crudia</i> (0.851)	<i>Crudia</i> -like	Striate, striae thick. Tectum is not clear, seems reticulate-foveolate. Internal arrangement of the wall is not clear due to degradation.
045.Striatopollis SA	South America	PETM	<i>Crudia</i> (0.459) <i>Cynometra</i> (0.325)	<i>Didelotia</i> (0.926) <i>Crudia</i> (0.907)	<i>Crudia</i>	Striate, tectum reticulate-foveolate. Striae are not clavate, neither rectangular.
046.Striatopollis SA	South America	PETM	<i>Crudia</i> (0.674)	<i>Didelotia</i> (0.929) <i>Crudia</i> (0.915)	<i>Crudia</i>	Striate, tectum reticulate. Striae clavate to mushroom-shaped. Internal arrangement of the wall is not clear due to degradation.
047.Striatopollis SA	South America	PETM	<i>Crudia</i> (0.904)	<i>Didelotia</i> (0.913) <i>Julbernardia</i> (0.899) <i>Crudia</i> (0.898)	<i>Crudia</i>	Striate, tectum reticulate-foveolate. Striae clavate to mushroom-shaped.
048.Striatopollis SA	South America	PETM	<i>Crudia</i> (0.517) <i>Berlinia</i> (0.399)	<i>Didelotia</i> (0.928) <i>Crudia</i> (0.911)	<i>Crudia/Berlinia</i>	Striate, tectum reticulate. Striae mushroom shaped. Striation similar to <i>Berlinia</i> . Pollen grain broken and internal arrangement of the wall is not clear due to degradation.
049.Ephedripites	Africa	Thanetian	<i>Neochevalierodendron</i> (0.48) <i>Anthonotha</i> (0.42)	<i>Julbernardia</i> (0.893)	No Amherstieae	Tectum with ridges, no supractum, no colpate.

**Movie S1 (separate file).** Reconstruction of the Cenozoic biogeography of *Striatopollis catatumbus*.

**Dataset S1 (separate file).** Record of relative abundance of *Striatopollis catatumbus* through the Cenozoic of northern South America. This record represents more than 15 years of palynological analysis.

**Dataset S2 (separate file).** Record of relative abundance of *Striatopollis catatumbus* from the geological sections analyzed in this study.

**Dataset S3 (separate file).** Information of Amherstieae herbarium specimens used for pollen extraction

**Dataset S4 (separate file).** Information of fossil specimens of *Striatopollis* used in this study.

**Dataset S5 (separate file).** Manual morphological measurements of extant Amherstieae species and fossil specimens of *Striatopollis catatumbus*.

**Dataset S6 (separate file).** Pairwise similarity matrix using the Euclidean distance of the NMDS1 and NMDS2. Similarity values vary from 0 to 1, in which 0 is most dissimilar and 1 is most similar.

**Dataset S7 (separate file).** Fossil record of *Striatopollis catatumbus* based on published literature.

## SI References

1. R. P. C. Temu, Taxonomy and biogeography of woody plants in the eastern Arc Mts, Tanzania: Case studies in *Zenkerella*, *Scorodophloeus* and *Peddiea*. *Acta Univ. Ups.* **286**, 1–68 (1990).
2. B. A. Mackinder, *et al.*, The tropical African legume *Scorodophloeus* clade includes two undescribed *Hymenostegia* segregate genera and *Micklethwaitia*, a rare, monospecific genus from Mozambique. *South African J. Bot.* **89**, 156–163 (2013).
3. A. Radosavljevic, P. S. Herendeen, B. A. Mackinder, Phylogeny of the Detarioid legume genera *Cynometra* and *Maniltoa* (Leguminosae). *Syst. Bot.* **42**, 670–679 (2017).
4. M. de la Estrella, *et al.*, A new phylogeny-based tribal classification of subfamily Detarioideae, an early branching clade of florally diverse tropical arborescent legumes. *Sci. Rep.* **8**, 6884 (2018).
5. A. Radosavljevic, The rise of *Cynometra* (Leguminosae) and the fall of *Maniltoa*: a generic re-circumscription and the addition of 4 new species. *PhytoKeys* **127**, 1–37 (2019).
6. A. Bruneau, M. Mercure, G. P. Lewis, P. S. Herendeen, Phylogenetic patterns and diversification in the Caesalpinoid legumes. *Botany* **86**, 697–718 (2008).
7. LPWG, A new subfamily classification of the Leguminosae based on a taxonomically comprehensive phylogeny. *Taxon* **66**, 44–77 (2017).